REMARKS

In the Office Action, the Examiner noted that claims 1 and 3-6 were pending in the application and the Examiner rejected all claims. By this amendment various claims have been amended and claim 5 has been cancelled. Thus, claims 1, 3, 4 and 5 are pending in the application. The Examiner's rejections are traversed below.

THE PRIOR ART REJECTIONS

In item 2 on pages 2-4 of the Office Action, the Examiner rejected claims 1 and 4-6 under 35 U.S.C. § 103 as obvious over U.S. Patent 4,402,053 to Kelley et al. in view of U.S. Patent 6,278,906 to Piepmeier et al. and U.S. Patent 6,597,971 to Kanno. In item 3 on pages 4-6 of the Office Action, the Examiner rejected claim 3 as unpatentable over Kelley et al. in view of Piepmeier et al.

The Kelley et al. Reference

The Kelley et al. reference is directed to a robot assembly in which a robot hand engages a workpiece at a selected holdsite. The workpiece is moved to a pose where the position and orientation of the workpiece are determined. Then, the workpiece may be disengaged or moved to an intermediate or final goalsite (see Abstract). Referring to Figs. 2 and 5, a first camera 42 is used to select holdsites on workpieces 80 in a bin 82. Because the camera is mounted on an arm, it can be used to view workpieces nearly anywhere in the bin 82 and at goalsites 100, 110 and 130. A second camera 44 is used to compute a workpiece presentation pose in the hand 26 (col. 7, lines 14-19). Kelley et al. discusses workpiece model matching involving computing image features necessary to determine orientation of the workpieces in the hand. The hand holds the workpiece and the assembly moves to a first presentation pose. Next, an image of the workpiece is formed using the work station camera, and image features are extracted. Their locations are computed and stored along with their properties. Then, the assembly moves the workpiece to the second presentation pose. Another image of the workpiece is formed using the workstation camera and image features are extracted. Their locations are computed and stored along with their properties. Features appearing in both images are paired and located in the space by using the camera model. The feature points and space are matched to pre-established workpiece features point model to determine the hand-workpiece relationship. The

recognizes the grip state of the workpiece while the workpiece is being moved by the robot to the release position, on the basis of the positions of the robot and the characteristic portion of the workpiece when the image is captured. The workpiece conveying apparatus also includes means for storing in advance a predetermined grip state established by the hand of the robot and mean for comparing the predetermined grip state with the grip state recognized by the visual sensor when the image is captured and determining an error. The apparatus further includes means for stopping the robot when the error exceeds a predetermined tolerance limit or for issuing a signal indicative of a fault.

The above features are not taught or suggested by Kelley et al. because Kelley et al. describes an arrangement in which workpieces are moved and then stopped at pose positions so that images of the workpiece can be formed. In contrast, in accordance with the present claimed invention of claim 1, the workpiece gripped state established by the hand can be observed while moving the robot. In addition, in accordance with the present invention as set forth in claim 1, a predetermined grip state (of a workpiece) established by the hand of the robot, which is stored in advance, is compared with a grip state (of the workpiece) at the time when the image is captured by the image pick-up means which is recognized by the visual sensor. These features are also not taught or suggested by Kelley et al. Further, the deficiencies of Kelley et al. are not cured by Kanno or Piepmeier et al.

On page 3 of the Office Action the Examiner takes the position that "it would have been obvious to one of ordinary skill in the art at the time of the invention to be able to take images of a workpiece as it is moving since it is well known in the art already that this can be done," relying on column 2, lines 38-53 of Piepmeier et al. This portion of Piepmeier et al. merely describes tracking of a moving target such as an automobile with cameras as it travels down a continuously moving assembly line. However, Piepmeier points out that these prior art controlled method are model based and required a precise kinematic model of the robot and the camera system geometry. That is, Piepmeier teaches away from the approach of tracking moving targets with cameras. Further, the brief description in Piepmeier relates to a workpiece continuously moving along an assembly line. This is significantly different from the claimed invention wherein the robot grips a workpiece and conveys the workpiece while an image of a characteristic portion of the workpiece is captured while the workpiece is being moved by the robot to a released position. Thus, even this short discussion in Piepmeier et al. is significantly different from the present invention as set forth in claim 1 which is directed to a robot having a hand to grip a workpiece and an image pick-up means for capturing an image of a characteristic portion of the workpiece while the workpiece is being moved by the robot to a release position.

assembly then moves to a goalsite via the through pose and places the piece within the proper pose at the goal. (Col. 13, lines 16-35)

The Kanno Reference

The Kanno reference is directed to an interference avoiding device for determining occurrence of an interference in a robot operation in advance and automatically avoiding the interference. The Examiner has cited Kanno for its disclosure at column 6, lines 52-57 of determining if interference cannot be avoided and displaying an alarm message on the display device of a robot controller, while stopping the operation of the robot 5.

The Piepmeier et al. Reference

The Piepmeier et al. reference is directed to an apparatus and method for enabling an uncalibrated, model independent controller for a mechanical system which incorporates velocity components of any moving system parameters. Piepmeier et al. discloses tracking of a moving target by a robot having multiple degrees of freedom. The Examiner has referenced Piepmeier et al., referring to column 5, line 50 to column 6, line 10 and column 6, lines 54-67 as well as column 2, lines 38-53. Piepmeier et al. states that tracking of moving targets with cameras is known in the art. Piepmeier states that such prior art controlled methods are model based and require a precise kinematic model of the robot and the camera system geometry (column 2, lines 38-53). However, Piepmeier et al. is directed to an uncalibrated, model independent controller for a mechanical system (column 3, lines 31-35).

THE PRESENT CLAIMED INVENTION PATENTABLY DISTINGUISHES OVER THE PRIOR ART

The present claimed invention as set forth in claim 1 is directed to a workpiece conveying apparatus comprising a robot having a hand to grip a workpiece and conveying the workpiece, and a visual sensor. The visual sensor includes a robot controller which detects the position of the robot, and image pickup means for capturing an image of a characteristic portion of the workpiece while the workpiece is moved by the robot to a release position. The visual sensor also includes position detecting means for detecting, on the basis of the image of the characteristic portion obtained by the image pickup means, a position of the characteristic portion of the workpiece observed when the image is captured. The robot controller includes means for synchronizing an image pick-up instruction given to said image pick-up means with said detection of the position of the robot at the time of image capture. The visual sensor

The grip state of the workpiece is recognized while the workpiece is being moved by the robot to the release position, on the basis of the positions of the robot and the characteristic portion of the workpiece when the image is captured. Thus, the claimed invention is directed to gripping a workpiece and moving the workpiece as opposed to a conveyer type of operation disclosed in Piepmeier. Therefore, it is submitted that Piepmeier does not teach or suggest the features of the present invention. As explained above, it is further submitted that Piepmeier actually teaches away from the claimed features of the present invention which require capturing an image of a characteristic portion of the workpiece while the workpiece is being moved by the robot to a release position and recognizing the grip state of the workpiece while the workpiece is being moved by the robot to the release position, on the basis of the positions of the robot and the characteristic portion of the workpiece when the image is captured. Thus, it is submitted that none of Kelley et al., Kanno or Piepmeier et al. teach or suggest the claimed workpiece conveying apparatus of claim 1 including:

> a robot having a hand to grip a workpiece and conveying the workpiece; and
>
> a visual sensor, comprising:
>
> a robot controller which detects the position of the robot;
>
> image pick-up means for capturing an image of a characteristic portion of the workpiece while the workpiece is being moved by said robot to a release position; and
>
> position detecting means for detecting, on the basis of the image of the characteristic portion obtained by said image pick-up means, a position of the characteristic portion of the workpiece observed when the image is captured,
>
> said robot controller including means for synchronizing an image pick-up instruction given to said image pick-up means with said detection of the position of the robot at the time of image capture,
>
> said visual sensor recognizing the gripped state of said workpiece while the workpiece is being moved by the robot to the release position, on the basis of the positions of the robot and the characteristic portion of the workpiece when the image is captured;
>
> means for storing in advance a predetermined gripped state established by the hand of said robot;
>
> means for comparing the predetermined gripped state with the

gripped state recognized by said visual sensor when the image is captured, and determining an error; and

means for stopping the robot when the error exceeds a predetermined tolerance limit or for issuing a signal indicative of a fault.

Therefore, it is submitted that claim 1 patentably distinguishes over Kelley et al., Kanno and Piepmeier et al.

It is also submitted that none of Kelley et al., Kanno et al. and Piepmeier et al. teach or suggest the features of claim 3 which include:

> a robot having a hand to grip a workpiece and conveying the workpiece; and
>
> a visual sensor, comprising:
>
> a robot controller which detects the position of the robot;
>
> image pick-up means for capturing an image of a characteristic portion of the workpiece while the workpiece is being moved by said robot to a release position; and
>
> position detecting means for detecting, on the basis of the image of the characteristic portion obtained by said image pick-up means, a position of the characteristic portion of the workpiece observed when the image is captured,
>
> said robot controller including means for synchronizing an image pick-up instruction given to said image pick-up means with said detection of the position of the robot at the time of image capture,
>
> said visual sensor recognizing the gripped state of said workpiece while the workpiece is being moved by the robot to the release position, on the basis of the positions of the robot and the characteristic portion of the workpiece when the image is captured;
>
> means for storing in advance a predetermined gripped state established by the hand of said robot;
>
> means for comparing the predetermined gripped state with

the gripped state recognized by said visual sensor to determine an error; and

means for correcting the release position to which said robot conveys the workpiece, on the basis of the error.

Therefore, it is submitted that claim 3 patentable distinguishes over Kelley et al., Kanno and Piepmeier et al. Claims 4 and 6 depend, directly or indirectly from claim 1 or claim 3 and include all the features of the claim from which they depend, plus additional features which are not taught or suggested by the prior art. Therefore, it is submitted that claims 4 and 6 patentably distinguish over the prior art.

SUMMARY

It is submitted that none of the references, either taken alone or in combination, teach the present claimed invention. Thus, claims 1 and 3, 4 and 6 are deemed to be in a condition suitable for allowance. Reconsideration of the claims and an early notice of allowance are earnestly solicited.

If there are any additional fees associated with filing of this Amendment, please charge the same to our Deposit Account No. 19-3935.

Respectfully submitted,

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